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# LINE X TESTER ANALYSIS FOR YEILD AND ITS COMPONENT AND GRAIN QUALITY CHARACTERS IN RICE

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## ABSTRACT

A Study on combining ability and heterosis were conducted on ١٢ F١ hybrids along with seven rice genotypes field experiment was carried out at the Farm of Rice Research and Training Center, Sakha, Kafr El-sheikh, Egypt using to line x tester mating design, during ٢٠١٢ and ٢٠١٣ seasons. The objectives of this investigation was aimed to know the pattern of inheritance of some grain yield and its component and grain quality characters in rice for selecting superior genotypes. The present investigation. The Line, GZ ٨٤٥٥-٦-٨-٣-١was earlier and shorter than other linens, its estimated values of days to complete heading and plant height were (٩٩ days and ٩٦,٢٤ cm), respectively. Among the linens, GZ ٨٣٧٢-١٣-١-٣-١ followed by GZ ٨٤٥٥-٦-٨-٣-١. were found to be longest panicle length, highest number of panicle per plant, lowest sterility %, heaviest ١٠٠ grain weight and highest grain yield per plant. On the other hand, Sakha ١٠٣ and Sakha ١٠٢ were found to be the earliest Testers. Moreover, Sakha ١٠١ was found to be the shortest tester. In addition GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ followed by GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ were the earliest rice cross combinations. While, the shortest plant height (٩٨,١٤ cm) was lasted from GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢.

Analysis of variance revealed significant differences among genotypes, crosses, lines, testers and line x tester interactions for yield and its component and grain quality characters. Both GCA and SCA Variances were highly significant for all the studied characters indicating the predominance of additive and non additive gene action in the inheritance of all characters. The estimated ratio of GCA/SCA was lower than unity for all the studied traits except days to complete heading trait, indicating the importance of non-additive gene action in the inheritance of all traits, except days to complete heading trait, which was fond to be controlled by additive gene action. The highest heterobeltiosis were obtained for cross GZ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ followed by GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ and GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ rice crosses for number of panicles/plant and head rice %, respectively. The proportional contribution of testers was observed to be higher than that of the interactions of line x tester that revealed the highest estimates of GCA variance.

The cross combinations GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣, GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ were observed to be good specific cross combinations for grain yield and grain quality characters to their highly significant SCA and heterobeltiosis effects. High broad sense heritability (٩٦,٢٣٪) was recorded for days to complete heading. While high narrow sense heritability was recorded for number of filled grains / panicle (٥٠,١٤٪). Highest estimates of expected genetic advance were observed for gel consistency and ١٠٠ grain weight. Highly significant and positive estimates of phenotypic correlation coefficient were found between grain yield and each of hulling %, milling %, head rice %, grain elongation, gel consistency and gelatinization temperature.

**Keywords:** Rice, Line x Tester, heterobeltiosis, combining ability, yield, its component and grain quality traits

# INTRODUCTION

Rice occupies an important position in the Egyptian economy. The total area under rice is about ١,١٠ million Fadden producing about ٦ million tones of paddy rice. Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability (SCA). The rice breeders often face with the problem of selecting parents and crosses for improving high yielding rice varieties. Combining ability analysis is one of the powerful tools available select the desirable parents and crosses for the exploitation of heterosis (Sarker *et al*., ٢٠٠٢; Radish *et al*., ٢٠٠٧). Presence of heterosis and SCA effects for yield and itsrelated traits are reported by Nuruzzaman *et al*., ٢٠٠٢; Faiz *et al*., ٢٠٠٦ and saleem *et al*., ٢٠٠٨. To exploit maximum heterosis using the hybrid programme, we must know the combining ability of different lines and restorers. The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering in formation on nature of gene effects and their expression in terms of combining ability is necessary. At the same time, it also elucidates the nature of gene action involved in the inheritance of characters. General combining ability (GCA) is attributed to additive gene effects and additive x additive epistasis and is theoretically fixable. On the other hand, specific combining ability attributable to non-additive gene action may be due to dominance or epistasis or both and is non-fixable. The presence of non-additive genetic variance is the primary justification for initiating the hybrid program (Cockerham, ١٩٦١; Pradhan *et al*., ٢٠٠٦). There is need to study various morphological traits to get better understanding of inheritance and select or identify superior genotypes. (Mishra and Verma ٢٠٠٢, Mahto *et al*., ٢٠٠٣ and Swati and Ramesh, ٢٠٠٤). Heterosis estimates were attributed to both additive and high degree of dominance or epistasic interactions and both for one or more yield, its component and grain quality characters. Vanaja and Babu (٢٠٠٤) pointed out that yield increase in rice was due to favorable heterosis in number of grains per panicle. In this paper an attempt has been made to assess the combining ability and to determine the nature and magnitude of gene action for yield and its related and grain quality characters to explore the best combination of hybrids for the exploitation of maximum heterosis or hybrid vigor in F١ hybrids for yield and its component (days to complete heading, plant height, panicle length, number of panicles per plant, number of filled grains per panicle, sterility %, ١٠٠ grain weight and grain yield traits), and grain quality characters (grain shape, hulling % milling %, head rice %, grain elongation %, gel consistency, gelatinization temperature and amylose content %).

# MATERIALS AND METHODS

## Plant materials

The experimental materials comprised seven rice genotypes, three genotypes (GZ ٨٣٧٢-١٣-١-٣-١, GZ ٨٩٥١-٩-٧-١-٣ and GZ ٨٤٥٥-٦-٨-٣-١) were used as females (designated as lines for high yielding ability, good grain quality and blast resistance) and four genotypes (Sakha ١٠١, Sakha ١٠٢, Sakha ١٠٣, Sakha ١٠٤) were used as males. These parents were crossed to produce ١٢ F١ hybrids using to line x tester mating design (Kempthorne, ١٩٥٧). This study was conducted during ٢٠١٢ and ٢٠١٣ seasons at Sakha Farm Station, Sakha Kafr El-sheikh, Egypt. Single seedlings of each entry were transplanted in ٢٠ x ٢٠ cm spacing at ٣ x ٥ m٢ plots in a randomized complete block design with three replications. The agronomic practices were done as recommended. In this study, eight characters, viz, yield and its component includes days to complete heading, plant height (cm), panicle length (cm), number of panicles per plant, number of filled grains per panicle, sterility percentage and grain yield per plant, these mentioned traits were evaluated based on standard evalution system of rice (Scshu, ١٩٨٨). Eight grain quality characters includes grain shape, hulling%, milling %, head rice %, grain elongation, gel consistence, gelatinization temperature and amylose content %. The last three traits were evaluated by Cagampang *et al* (١٩٧٣), Little *et al*. (١٩٥٨) And Williams *et al*.(١٩٥٨).

**Statistical analysis**

Data were recorded on twenty randomly selected plants from parents and F١s plant samples. Combining ability analysis was done using line x tester method (Kempthorne, ١٩٥٧). The variances for general combining ability and specific combining ability were tested against their respective error variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were performed using t-test. Heterobeltiosis and Heritability were determined as outlined by Falconar and Mackay (١٩٩٦). Expected genetic advance was calculated by Johanson *et al* (١٩٥٥). Phenotypic correlation coefficient was performed according to Dewey and Lu (١٩٥٩).

## RESULTS AND DESICATION

**Means performance**

Means of lines, testers and their hybrids for yield and its components were reported in Table ١ indicated worth of genetic variability for the improvement each of days to complete heading, plant height (cm), panicle length (cm), number of panicles per plant, number of filled grains per panicle, sterility percentage and grain yield per plant which are important in rice yield. Line, GZ ٨٤٥٥-٦-٨-٣-١was earlier (٩٩ days) than other lines and shortest one (٩٦,٢٤ cm) in plant height. Longest panicle length, highest number of panicles per plant, lowest sterility %, heaviest ١٠٠grain weight and grain yield per plant were recorded for GZ ٨٣٧٢-١٣-١-٣-١ and GZ ٨٤٥٥-٦-٨-٣-١. Also Sakha ١٠٢ tester was earlier than the other testers follwed by Sakha ١٠٣. While Sakha ١٠١ is the shortest tester. follwed by Sakha ١٠٣. longest panicale, highest number of panicles, number of filled grains per panicle, ١٠٠ grain weight and grain yield per plant were recorded from testers, Sakha ١٠١ and Sakha ١٠٤, respectively. On the contrary, lowest sterility percentage was obtained from tester of sakha ١٠٢. The earliest cross combinations were obtained for GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ followed by GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤. While the shortest plant hight was lasted from GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ (٩٨,١٤ cm) followed by GZ ٨٣٩٥١-٩-٧-١-٣ x Sakha ١٠١ (١٠٠,٤٧cm). On the other hand, the longest panicle length was obtained from GZ٨٣٩٥١-٩-٧-١-٣ x Sakha ١٠١ (٢٧,٥١ cm). followed by GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ (٢٦,٨٥ cm). Highest number of panicles per plant, number of filled grains per panicle, ١٠٠ grain weight and grain yield per plant were recorded for GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١, GZ٨٩٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤, respectively.

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Means of lines, testers and their hybrids for grain quality characters (Table ٢) showed that wide of genetic variability for the improvement of grain shape, hulling%, milling%, head rice %, grain elongation%, gel consistency, gelatinization temperature and amylose content %. Highest mean values of grain shape, hulling%, milling%, head rice%, grain elongation%, gel consistency, gelatinization temperature were obtained from lines GZ ٨٩٥١-٩-٧-١-٣ and GZ ٨٤٥٥-٦-٨-٣-١, respectively but GZ ٨٤٥٥-٦-٨-٣-١ was the lowest one for amylose content %. Testers, Sakha ١٠٢ and Sakha ١٠٣ gave highest mean values for grain shape. On the other hand, tester Sakha ١٠١ gave highest mean values for hulling%, milling% and head rice %. While the longest grain was recorded from Sakha ١٠٣ (٠,٨٣cm). Whereas the best gel consistency was obtained from Sakha ١٠٣ followed by Sakha ١٠٤ tester. Concerning cross combination, the bold grain shape (٢.٧٤), (٢,٦٥) and (٢,٦٤) were lasted from three crosses GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٢, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣ and GZ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١, respectively. The highest main of hulling%, milling% and head rice % were obtained from GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ crosses. While the longest mean of grain elongation was recorded from GZ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٣ followed by GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١. On the other hand, the cross GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ gave the highest mean of gelatinization temperature. Whereas, low gelatinizing temperature and amylose content % were obtained from GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣.Significant differences among various traits have been reported by Surek and Korkut, (٢٠٠٢); Swati and Ramesh, (٢٠٠٤) and El-Abd *et al* (٢٠٠٧). Their results showed that different genetic systems involved in controlling characters, which emphasized on important of study of these characters.

**Combining ability analysis**

There were significant differences among studied genotypes for yield and attributes as well as grain quality characters (Table ٣ and ٤) due to analysis of variance, which lead to the combining ability analysis. Thus were partitioned genetic effects between genotypes into General Combining Ability and Specific Combining Ability. Therefore, for days to complete heading and plant height negative GCA and SCA effects were desirable, while in case of other characters positive GCA and SCA effects were desirable.

Analysis of variance of combining ability for yield and its component and grain quality characters are presented in Tables ٣ and ٤. Analysis of variance of combining ability for yield, its component and grain quality characters revealed significant differences among genotypes, crosses, lines, testers and line x tester interactions. The significant differences among the lines, testers and lines x testers indicated that the genotypes had wide genetic diversity among themselves for all traits. The significant of the means of sum of squares due to lines and testers indicated a prevalence of additive variance. However, significant differences due to interactions of line x tester for all the characters, indicating the importance of both additive and non-additive variance. Variances of SCA were higher than the GCA variances for yield, its component and grain quality characters except for days to complete heading and gel consistency which indicated preponderance of non-additive gene action in the inheritance of the traits.

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This was further supported by low magnitude of gca/sca ratios (Table ٣ and ٤). It suggested greater importance of non-additive gene action in its expression and indicated very good prospect for the exploitation of non-additive genetic variation for traits through breeding program (Ramalingam, ١٩٩٧; Annadurai and Nadarajan ٢٠٠١ and El-Abd *et al* ٢٠٠٧).

**General combining ability effects:**

General combining ability effects of lines and testers for yield and its component characters are presented in Table ٥. Variation in general combining ability (GCA) effects was estimated among lines and testers for eight plant characters of yield and its component to identify the best parent for subsequent hybrid development program. The results of days to complete heading and plant height showed negative GCA effects, while in case of other characters positive GCA effects are desirable. Minimum plant height is needed to protect the crop from lodging. Therefore, GZ ٨٩٥١-٩-٧-١-٣ was a potential female parent and has highly significant GCA effect in the desirable direction (negative direction) for days to complete heading and plant height. These findings are in accordance with Sarker *et al*., (٢٠٠٢). The female line, GZ ٨٩٥١-٩-٧-١-٣ indicated highly significant GCA effects for panicle length, number of panicle per plant, number of filled grains per panicle, ١٠٠ grain weight and grain yield per plant. These results are in conformity with Singh and Kumar (٢٠٠٤) and El-Abd *et al* (٢٠٠٧).

Among testers Sakha ١٠٢ is the potential male parent having negative and highly significant GCA effects for days to complete heading and plant height thus confirming the findings of Roy and Mandal (٢٠٠١) and Shehata, (٢٠٠٤). Among testers, positive GCA effects are important for panicle length. Therefore the tester Sakha ١٠٢ having the positive and highly significant GCA effect was the potential parent which the selection will be effective for their efficient use in subsequent hybrids development with more longest panicle length. These results are in line with Roy and Mandal (٢٠٠١) and Sarker *et al*. (٢٠٠٢). The male parents Sakha ١٠١ and Sakha ١٠٤ showed highly significant GCA effects for number of panicles per plant, number of filled grains per panicles, ١٠٠ grain weight and grain yield per plant. respectively. However, Sakha ١٠٢ indicated negative and highly significant GCA effect for sterility %.

General combining ability effects of lines and testers for eight grain quality characters are presented in Table ٦. Variation in general combining ability (GCA) effects was estimated among lines and testers. The results of gelatinization temperature and amylose content % showed negative GCA effects, while in case of other characters positive GCA effects are desirable. Therefore, GZ ٨٣٧٢-١٣-١-٣-١ and GZ٨٩٥١-٩-٧-١-٣ is a potential female parent and has highly significant GCA effect in the desirable direction for gelatinization temperature and amylose content %. The female line GZ ٨٩٥١-٩-٧-١-٣ indicated highly significant GCA effects for hulling % milling %, head rice %, grain elongation % and gel consistency traits.

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Concerning testers Sakha ١٠٤ was the potential male parent having positive and highly significant GCA effects for grain shape, hulling % milling %, head rice %, grain elongation %, gel consistence and negative highly significant for gelatinization temperature and amylose content %. Among testers, positive GCA effects are important for panicle length. Therefore the tester Sakha ١٠٤ having the positive and highly significant GCA effect. The potential parent wherein the selection will be effective for their efficient use in subsequent hybrids development.

**Specific combining ability effects:**

The estimates of specific combining ability effects of ١٢ rice hybrids for yield and its component are presented in Table ٧. Low days to complete heading and Minimum plant height was desirable trait of rice crop. The cross GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ was the best showing negative and significant combining ability effect of -٦,٢٦ and -٧,٤١ for days to complete heading and plant height respectively. The results confirm the findings of Rogbell *et al*. (١٩٩٨), Roy and Mandal (٢٠٠١), Sarker *et al*. (٢٠٠٢), Shehata (٢٠٠٤). and El-Abd *et al* (٢٠٠٧). Increased panicle length and more number of panicles per plant were also a desirable trait of rice hybrids with increased yield/plant. The cross combinations namely GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤ and GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ possess highly significant and positive SCA effects for panicle length and number of panicles per plant. These studies was in conformity with the reports of El-Abd *et al* (٢٠٠٧). The positive and significant SCA effect for number of filled grains per panicle was recorded in five crosses combinations i.e., GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤, GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١, GZ ٨٤٥٣-٦-٨-٣-١ x Sakha ١٠١ and GZ ٨٤٥٣-٦-٨-٣-١ x Sakha ١٠٤, whereas GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ ٨٤٥٣-٦-٨-٣-١ x Sakha ١٠٤ exhibited negative and highly significant SCA effects for sterility %, while GZ ٨٤٥٣-٦-٨-٣-١ x Sakha ١٠٢ have highly significant positive SCA effect for ١٠٠-grain weight. These results are in line with the findings of Roy and Mandal (٢٠٠١) and Singh and Kumar (٢٠٠٤). The grain yield/plant is an ultimate objective of rice breeding and hybrid development programs. The cross combinations GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣, GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ ٨٣٧٢-١٣-١-٣-١ Sakha ١٠١ revealed positive and highly significant SCA effects for yield/plant. This is in agreement with the results obtained by Ganesen and Rangaswamy (١٩٩٧), Roy and Mandal (٢٠٠١), Sarker *et al*., (٢٠٠٢) and Singh and Kumar (٢٠٠٤).

The estimates of specific combining ability effects of ١٢ rice hybrids for yield and its component are presented in Table ٨. The results showed highly significant and positive SCA for grain shape was obtained from GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ ٨٤٥٥-٦-٥-٣-١ x Sakha ١٠٤. While highly significant and positive SCA for hulling %, milling % and head rice % were recorded from GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤, GZ ٨٤٥٥-٦-٥-٣-١ x Sakha ١٠٤ and GZ ٨٤٥٥-٦-٥-٣-١ x Sakha ١٠١ crosses respectively. Longest of grain elongation was desirable trait of rice grain quality, there for highly significant and positive SCA was recorded from GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ and GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ crosses. On the contrary, cross combinations namely, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ possess highly significant and negative SCA effects for gelatinization temperature and amylose content %.

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The information on the nature of gene action with respective variety and characters might be used depending on the breeding objectives. Investigation of GCA effects revealed that among lines and testers were good general combiners for grain yield and the other traits. Hence these good general combiners of males and females may be extensively used in future for hybrid rice breeding program. Determine the usefulness of a particular cross combination in the exploitation of heterbeltosis. In the present study, SCA effects in six crosses were highly significant and positive for grain yield. Majority of these hybrids involved at least one parent with positive GCA effect. Similar results have been reported by Rao *et al*. (١٩٩٦).

Among the six crosses GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣, GZ ٨٣٧٢-١٣-١-٣-١ Sakha ١٠٤ and GZ ٨٣٧٢-١٣-١-٣-١ Sakha ١٠١ which depicted highly significant positive SCA effects for grain yield, only one crosses(GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١) showed high heterobeltiosis (Table ٩). Dhaliwal and Sharma (١٩٩٠) reported that non-additive gene effects were predominant for yield and its components. It is evident that cross combinations, which expressed high SCA effects for grain yield have invariably exhibited positive SCA effects for one or more yield related traits also. While selecting the best specific combination for yield, it would be important to give due weight age to yield related traits. Grafius (١٩٥٩) had already suggested that there is no separate gene for yield, but yield is an end product of multiplicative interaction among various yield components.

**Heterosis:**

Percent heterobeltosis was calculated for eight yield, its components (Table ٩). The degree of heterobeltosis varied from cross to cross and from character to character. Alam *et al*., (٢٠٠٤) and Shehata, S.M (٢٠٠٤). negative heterobeltiosis was desirable for days to complete heading and plant height but for rest of the characters positive heterobeltiosis was desirable. Highly significant and negative heterobeltiosis were lasted from crosses combination GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ and GZ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤. Positive heterobeltosis and highly significant for panicle length was recorded from GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١. While highly significant and positive heterobeltiosis for number of panicles per plant was recorded from GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ followed by GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢. On the other hand highly significant and positive heterobeltosis for number of field grains / panicle, ١٠٠ grain weight and grain yield were recorded from GZ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ respectively. The results were agreed with Watanesk (١٩٩٣), Rao *et al*., (١٩٩٦), Li *et al*., (١٩٩٧), Perera *et al*., (٢٠٠١), Nuruzzaman *et al*., (٢٠٠٢) and El-Abd *et al* (٢٠٠٧).

Percent heterobeltosis was calculated for eight grain quality characters (Table ١٠). Highest significant and positive degree of heterobeltosis for grain shape, hulling%, milling% and head rice% were recorded from GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ cross. While highly significant and positive heterobeltosis for grain elongation and gel consistence were leasted from GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ cross. on the contrary highly significant and negative heterobeltosis for gelatinization temperature and amylose content % was obtained from cross GZ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١.

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In view of this, it appears that heterobeltosis for yield may be through heterobeltosis for individual yield components or alternatively due to multiplication effects of non-additive gene effects of component characters. Generally, high x high, low x high and high x low general combiner parents produced good specific cross combinations. In these crosses additive x additive, dominance x additive and additive x dominance type of gene action was found. In cases, high x high general produced inferior cross combinations indicating epistatic type of gene action for these traits. Six good specific cross combinations GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣, GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ might be released as promising lines for commercial utilization after further study. Ultimate aim of breeding is to gain the heterotics yield associated with other heterotic characters. Yield is the complex character of all other yield contributing characters. Percent better parents were calculated for grain yield and seven yield related traits (Table ٩). The degree of heterosis varied from cross to other and from character to other. Concerning days to complete hading, plant height, gelatinization tempreture and amylose content negative heterobeltosis were desirable but for rest of the characters positive heterobeltosis were desirable. Desirable and significant heterobeltosis for grain yield was found in five crosses namely, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠١, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤, GZ ٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١, GZ ٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣, GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ and GZ ٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ associated with higher heterosis for most of the yield related traits.

**Estimates of heritability and expected genetic advance:**

It is clear from Table (١١) that Heritability in broad sense estimates ($h^{٢}b.$) were higher than their corresponding ones of narrow sense heritability ($h^{٢}n.$) for all studied characters. High broad sense heritability (٩٦,٢٣٪) was recorded for days to complete heading. It was found to be moderate (٧٩,٥٤٪) for milling % and to high for panicle length (٩٥,٨٦٪). High narrow sense heritability was recorded for number of filled grains/panicle (٥٠,١٤٪), while it was ranged from low to moderate, in other remaining grain yield and gain quality traits. The variation among the heritabilities in both broad and narrow sense values might be due to either gene expression of the trait. The results also revealed that the magnitude of heritability in narrow sense was lower than its corresponding for all studied characters, suggesting the increase contribution of additive gene effect. Additive gene affects increased in the subsequent generation, which help the breeders to select the best genotypes in this generation. So, these materials could successfully be used in the rice breeding program.

The highest estimates of expected genetic advance were observed for gel consistency and ١٠٠ grain weight. While, the low estimates were detected for amylose content %, indicating that additive genetic variance played an important role in the inheritance of these traits. Moreover, low to moderate estimates of heritability in narrow sense, accompanied with low to moderate expected genetic advance were recorded for most of the studied traits, lead to conclude that effectiveness of selection of most studied traits might be practiced in the advanced generations. These results wire in harmony with those of Abd-Allah (٢٠٠٠), Abd El-Aty *et al.* (٢٠٠٢), Hammoud *et al.* (٢٠٠٦) Abd El-Lattef and Badr (٢٠٠٧) and Abdel-latef *et al.,* (٢٠١١).

**Table ١١. Estimates of broad (h٢b) and narrow (h٢n) sense heritability' % and expected genetic advance (GS%) for grain yield and grain quality characters.**

| Characters | h٢b | h٢n | GS% |
|---|---|---|---|
| Days to complete heading (days) | ٩٦,٢٣ | ٤٢,٢٣ | ٢٢,٤٥ |
| Plant height (cm) | ٩١,٥٤ | ٣٩,٢٦ | ١٩,٤٣ |
| Panicle length (cm) | ٩٥,٣٦ | ٤٠,١٢ | ١١,٢٤ |
| No. of panicles /plant | ٩١,٤٥ | ٤١,٢٨ | ١٥,٣٦ |
| No. of filled grains /panicle | ٨٥,٤٧ | ٥٠,١٤ | ١٢,٦٤ |
| Sterility % | ٩٤,٥٨ | ٣٥,٢٦ | ١٣,٢٩ |
| ١٠٠-grain weight(g) | ٧٤,٢٦ | ٣١,٥٤ | ١٢,٥٤ |
| Grain yield/plant | ٨٦,٥٩ | ٤٩,٣٨ | ٢٥,٩٨ |
| Grain Shape% | ٩٠,١٢ | ٣٥,٤٨ | ٢٢,٥٧ |
| Hulling % | ٨٣,٥٤ | ٤٠,١٥ | ١٣,٤٥ |
| Milling % | ٧٩,٥٤ | ٣٩,٥٧ | ٢٤,٥٩ |
| Head Rice % | ٨٥,٤٧ | ٢٢,٣٥ | ٢١,٥٧ |
| Grain Elongation % | ٩٠,٣٤ | ٣٦,٤٨ | ١٧,٣٦ |
| Gel Consistence | ٩٢,٥٦ | ٣٠,٥٤ | ٢٦,٤٨ |
| Gelatinization Temperature | ٨٣,٣٥ | ٢٤,١٨ | ١٨,٦٧ |
| Amylose content % | ٩٤,٢٨ | ٣٢,٤٩ | ٩,٢٧ |

**Estimates of phenotypic correlation coefficient:**

Phenotypic correlation coefficients among all possible pars of the studied traits are presented in (Table ١٢ ). Highly significant and positive estimates of phenotypic correlation coefficient were found between grain yield and each of hulling %, milling %, head rice %, grain elongation, gel consistency and gelatinization temperature, while, it was significantly and positively associated with amylose content %. While, it was found to be highly significantly and positively associated between number of filled grains / panicle and hulling %, milling % and head rice. Moreover, significant and positive estimates of phenotypic correlation coefficient were recorded for ١٠٠ grain weight with milling % and head rice %. Sterility % was negatively correlated with milling and head rice %. However, insignificant either positive or negative estimates of phenotypic correlation coefficient were recorded among other remaining traits. These results ware in agreement with those of Abd- Allah (٢٠٠٠), Abd El-Lattef *et al.* (٢٠٠٦) El-Abd *et al.* (٢٠٠٧) and Abdel-latef *et al.,* (٢٠١١).

**Table ١٢. Estimates of phenotypic correlation coefficients among between grain yield an grain quality characters.**

| Characters | Hulling % | Milling % | Head Rice % | Grain Elongation % | Gel Consistence | Gelatinization Temperature | Amylose content % |
|---|---|---|---|---|---|---|---|
| Plant height (cm) | ٠,٢٢ | ٠,٢١ | ٠,٢٦ | ٠,١٧ | ٠,٢٢ | ٠,٢٥ | ٠,١٨ |
| Panicle length (cm) | ٠,٢٩ | ٠,١٨ | ٠,٢٥ | ٠,٢٢ | ٠,٢٤ | ٠,١٨ | ٠,٢١ |
| No. of panicles /plant | ٠,٣٢* | ٠,٢٥ | ٠,٢٨ | ٠,١٨ | ٠,٢٨ | ٠,٢١ | ٠,١٦ |
| No. of filled grains /panicle | ٠,٣٨** | ٠,٣٦** | -٠,٤٢** | ٠,٢١ | ٠,١٨ | ٠,٢٩ | ٠,٢٢ |
| Sterility % | ٠,٣٦** | -٠,٣٨** | -٠,٣٩** | ٠,٢٢ | ٠,١٤ | ٠,٢٤ | ٠,٢٣ |
| ١٠٠-grain weight(g) | ٠,٢٨ | ٠,٣٢* | ٠,٣٦** | ٠,٢٨ | ٠,٣٥** | ٠,٣٦** | ٠,٢٢ |
| Grain yield/plant | -٠,٤٢** | -٠,٣٦** | -٠,٤٠** | ٠,٣٨** | ٠,٤١** | ٠,٣٨** | ٠,٣٢* |

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## تحليـل السـلالات والسـلالات الاخويـة لمحصـول الارز ومكوناتـة وصـفات الجـودة للحبوب

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اجريت دراسة القدرة على التآلف وقوة الهجين مقارنة باقضل الاباء لمحصول الحبوب باستخدام نظام السلالات والسلالات الاخوية حيث تم استخدام ٧ تراكيب وراثية ثلاثة منها استخدمت كامهات وهى (GZ ٨٣٧٢-١٣-١-٣-١, GZ ٨٩٥١-٩-٧-١-٣ and GZ ٨٤٥٥-٦-٨-٣-١) واربعة تم استخدامهم كاباء وهى سخا ١٠١ و سخا ١٠٢و سخا ١٠٣و سخا ١٠٤ وذلك بهدف انتاج ١٢ تركيب وراثي مختلف بغرض دراسة توارث صفات المحصول والجودة للحبوب وذلك بمحطة البحوث الزراعية بسخا أثناء موسمى ٢٠١٣ و٢٠١٢.

**وكانت أهم النتائج المتحصل عليها كالا تى:-**

١-اوضحت النتائج تفوق السلالة جى زد ٨٤٥٥-٦-٨-٣-١ فى صفة التبكير وطول النبات مقارنة بباقى السلالات بينما تفوقت السلالتين جى زد ٨٣٧٢-١٣-١-٣-١ و جى زد ٨٤٥٥-٦-٨-٣-١ فى كل من صفات طول الدالية وعدد الداليات بالنبات الفردى والنسبة المؤوية للعقم و ووزن المائة حبة و محصول الحبوب بالنبات الفردى. اشارت النتائج تفوق الصنف سخا ١٠٢ فى صفة التبكير بينما تفوق الصنف سخا ١٠١ فى صفة طول النبات الفردى. تفوق الهجين جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠٤ فى صفة التبكير بينما جاء الهجين جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠٢ اقصر الهجن فى صفة طول النبات الفردى

٢-اظهرت النتائج اختلاف معنوى واضح بين السلالات والسلالات الاخوية والهجن الناتجة منهما لصفات المحصول ومكوناتة وكذالك صفات الجودة للحبوب كما جاء تباين القدرة الخاصة على التالف اعلى من القدرة العامة على التالف لكل الصفات المدروسة ما عدا صفة التزهير.

٣-لقد سجلت اعلى قيمة لقوة الهجين (٣٠,٢٤%) من التهجين بين جى زد ٨٩٥١-٩-٧-١-٣ x سخا ١٠٣ لصفة عدد الداليات بالنبات الفردى. سجلت صفة التزهير اعلى قيمة عالية المعنوية وموجبة فى درجة التوريث فى المدى الواسع بينما سجلت صصفة عدد الحبوب الممتلئة اعلى قيمة لدرجة التوريث فى المدى الضيق بينما سجلت صفة نسبة الجل ووزن ال١٠٠ حبة قيمة عالية للنسبة التقدم الوراثى.

٤-اظهرت النتائج ارتباط معنوى موجب لصفة محصول النبات الفردى مع كل من صفان النسبة المؤوية للتقشير والنسبة المؤوية للتبيض ونسبة الهد ريز وطول الحبة بعد الطهى ونسبة الجل بالحبة ودرجة الجلتنة.

توصى النتائج باستخدام الهجن التالية جى زد ٨٩٥١-٩-٧-١-٣ x سخا ١٠١ و جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠٤ و جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠١ و جى زد ٨٩٥١-٩-٧-١-٣ x سخا ١٠٣ و جى زد ٨٣٧٢-١٣-١-٣-١ x سخا ١٠٤ و جى زد ٨٣٧٢-١٣-١-٣-١ x سخا ١٠١ كافضل تراكيب وراثية لصفات المحصول والجودة للحبوب وبالتالى يمكن الاستفادة بها فى برامج التربية.

**Table ١. Means of the estimated grain yield and its related characters using Lins x Testers in١٢ F١ rice cross combinations.**

| genotypes | **Days to complete heading (days)** | **Plant height (cm)** | **Panicle length (cm)** | **No. of panicles /plant** | **No. of filled grains /panicle** | **Sterility %** | **١٠٠-grain weight(g)** | **Grain yield/plant** |
|---|---|---|---|---|---|---|---|---|
| **Line** | | | | | | | | |
| ١- GZ-٨٣٧٢-١٣-١-٣-١ | ١١١ | ١٠٧,٢ | ٢٦,١ | ٢٦,٤ | ١٥٠,٢ | ١٤,١ | ٢,٦ | ٤٩,٢ |
| ٢- GZ-٨٩٥١-٩-٧-١-٣ | ١٠٢ | ١٠٥,٣ | ٢٣,٤ | ٢٠,١ | ١٦٩,٣ | ١٦,٢ | ٢,٥ | ٤٦,٣ |
| ٣- GZ-٨٤٥٥-٦-٨-٣-١ | ٩٩ | ٩٦,٢ | ٢٥,٣ | ٢٤,٣ | ١٧٢,٤ | ١٨,٦ | ٢,٥ | ٤٨,٣ |
| **Testers** | | | | | | | | |
| ٤- Sakha ١٠١ | ١١٤ | ٩٨,٧ | ٢٥,٦ | ٢٢,١ | ١٦٢,٣ | ١٥,٢ | ٢,٦ | ٤٤,٢ |
| ٥- Sakha ١٠٢ | ٩٥ | ١٠٠,٢ | ٢٠,٤ | ٢٠,٤ | ١٢٥,٤ | ١٤,٨ | ٢,٥ | ٤٠,٢ |
| ٦- Sakha ١٠٣ | ٩٠ | ٩٩,٣ | ٢١,٨ | ٢١,٣ | ١٣٩,٤ | ١٦,٣ | ٢,٥ | ٤٢,٣ |
| ٧- sakha ١٠٤ | ١٠٦ | ١٠٩,٣ | ٢٣,٥ | ٢١,٤ | ١٤٥,٣ | ١٥,٢ | ٢,٧ | ٤٣,٣ |
| **Crosses** | | | | | | | | |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ | ١٠٥,٢ | ١٠٥,٤ | ٢٤,٦ | ٢٥,٤ | ١٦١,٢ | ١٥,٢ | ٢,٦ | ٤٥,٣ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٢ | ١٠٠,٦ | ١٠٠,٣ | ٢٢,٥ | ٢٥,٧ | ١٣٤,٧ | ١٤,٦ | ٢,٦ | ٤٢,٣ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٣ | ١٠٨,٧ | ١٠١,٢ | ٢٣,٦ | ٢٣,١ | ١٤٩,٣ | ١٥,٢ | ٢,٥ | ٤٤,١ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ | ١٠٥,٤ | ١١٠,٣ | ٢٤,٦ | ٢٧,٥ | ١٦٠,٥ | ١٦,٤ | ٢,٧ | ٤٩,٢ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ | ١٠١,٣ | ١٠٠,٤ | ٢٧,٥ | ٢٧,٦ | ١٧١,٤ | ١٥,٣ | ٢,٦ | ٤٩,٧ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ | ١٠٠,٤ | ١٠٢,٣ | ٢٦,٨ | ٢٥,٣ | ١٤٢,٣ | ١٣,٦ | ٢,٥ | ٤٣,٢ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ | ١٠٣,٢ | ١٠١,٤ | ٢٤,٩ | ١٩,٣ | ١٥٥,١ | ١٥,٤ | ٢,٥ | ٤١,٣ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤ | ١٠٤,٣ | ١٠٨,٩ | ٢٥,٤ | ٢٥,٧ | ١٥٥,٤ | ١٦,٥ | ٢,٦ | ٤٨,٩ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ | ١٠٢,٣ | ١٠٨,٤ | ٢٤,٦ | ٢٣,٢ | ١٦٩,٣ | ١٧,٦ | ٢,٦ | ٤٥,٣ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ | ٩٦,٤ | ٩٨,١ | ٢٤,٦ | ٢٣,١ | ١٤٤,٧ | ١٦,٤ | ٢,٥ | ٤٢,٣ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣ | ١٠٢,٣ | ١٠٣.٤ | ٢٥,٤ | ٢٢,٣ | ١٥٨,٤ | ١٥,٧ | ٢,٥ | ٤٠,٢ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ | ٩٧,٢ | ١٠٦,٣ | ٢٥,١ | ٢٣,٣ | ١٦٠,٢ | ١٥,٢ | ٢,٦ | ٤٣,٢ |
| LSD ٥ % | ١,٣ | ٢,٤ | ١,٠ | ٢,١ | ٣,٢ | ١,٢ | ٠,٢ | ٢,٤ |
| LSD ١ % | ٢,٤ | ٣,٦ | ٢,٣ | ٣,٤ | ٤,٢ | ٢,١ | ٠,٦ | ٣,٢ |

**Table ٢. Means of the estimated grain quality characters using Lins x Testers in١٢ F١ rice cross combinations.**

| genotypes | Grain Shape% | Hulling % | Milling % | Head Rice % | Grain elongation % | Gel consistence | Gelatinization temperature | Amylose content % |
|---|---|---|---|---|---|---|---|---|
| **Line** | | | | | | | | |
| GZ-٨٣٧٢-١٣-١-٣-١ | ٢,٥ | ٧٩,٢ | ٧٣,٢ | ٦٥,٥ | ٠,٦٩ | ٩٠,٢ | ٦,٦ | ٢٧,٨ |
| GZ-٨٩٥١-٩-٧-١-٣ | ٢,٦ | ٨٢,٣ | ٧٤,٦ | ٦٦,٤ | ٠,٧٢ | ٨٦,٤ | ٦,٥ | ١٩,٤ |
| GZ-٨٤٥٥-٦-٨-٣-١ | ٢,٥ | ٨٣,٢ | ٧٤,١ | ٦٧,٤ | ٠,٧٤ | ٨٨,٥ | ٦,٦ | ١٨,٧ |
| **Testers** | | | | | | | | |
| Sakha ١٠١ | ٢,٣ | ٨٢,٣ | ٧٤,٦ | ٦٩,٢ | ٠,٧٩ | ٩٠,١ | ٦,٤ | ١٨,٦ |
| Sakha ١٠٢ | ٢,٤ | ٨٠,٢ | ٧٠,١ | ٦٧,٤ | ٠,٧١ | ٨٩,٧ | ٦,٢ | ١٩,٢ |
| Sakha ١٠٣ | ٢,٣ | ٧٩,٦ | ٧١,٤ | ٦٤,٨ | ٠,٨٢ | ٩٣,٥ | ٦,٥ | ١٨,٣ |
| Sakha ١٠٤ | ٢,٣ | ٨١,٦ | ٧٣,٨ | ٦٨,٨ | ٠,٧٨ | ٩١,٤ | ٦,٣ | ١٦,٥ |
| **Crosses** | | | | | | | | |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ | ٢,٤ | ٨٢,٢ | ٧٤,٦ | ٦٩,١ | ٠,٧٦ | ٨٨,٦ | ٦,٦ | ٢٢,٧ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٢ | ٢,٧ | ٨١,٦ | ٧٢,٥ | ٦٨,٥ | ٠,٧٢ | ٨٥,٨ | ٦,٣ | ٢٥,٢ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٣ | ٢,٥ | ٨٠,٤ | ٧٠,٩ | ٦٥,٦ | ٠,٧٩ | ٩١,٦ | ٦,٥ | ٢٣,٥ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ | ٢,٥ | ٨٣,٤ | ٧٥,٣ | ٦٩,٤ | ٠,٧٥ | ٨٩,٨ | ٦,٣ | ١٧,٢ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ | ٢,٤ | ٨٢,٤ | ٧٤,٩ | ٦٠,١ | ٠,٧٥ | ٨٩,٧ | ٦,٣ | ١٩,٧ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ | ٢,٦ | ٨١,٦ | ٧٢,٥ | ٦٧,٢ | ٠,٧٠ | ٨٧,٢ | ٦,٢ | ١٩,٦ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ | ٢.٤ | ٨٠,٥ | ٧٣,٦ | ٦٥,١ | ٠,٧٦ | ٩٢,٧ | ٦,٤ | ١٩,٥ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤ | ٢,٥ | ٨٠,٢ | ٧١,٣ | ٦٦,٨ | ٠,٧٥ | ٨٧,٣ | ٦,٣ | ٢٠,٢ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ | ٢,٦ | ٧٩,٦ | ٧٠,٢ | ٦٤,٣ | ٠,٧١ | ٩٠,٢ | ٦,٣ | ١٨,٦ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ | ٢,٥ | ٨٠,٦ | ٧٤,٣ | ٦٢,٥ | ٠,٧٥ | ٨٦,٣ | ٦,٨ | ١٧,٣ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣ | ٢,٦ | ٨٠,٧ | ٧١,٣ | ٦٥,٤ | ٠,٧٣ | ٨٣,٦ | ٦,١ | ١٦,٣ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ | ٢,٣ | ٧٨,٣ | ٧٠,٢ | ٦٤,٦ | ٠,٧٢ | ٨٥,٢ | ٦,٨ | ١٦,٣ |

**Table ٣: Analysis of variance for combining ability of rice yield and its component characters.**

| Source of variance | df | Days to complete heading(days) | Plant height (cm) | Panicle length (cm) | No. of panicles /plant | No. of filled grains/panicle | Sterility % | ١٠٠-grain weight(g) | Grain yield/plant |
|---|---|---|---|---|---|---|---|---|---|
| Replication | ٢ | ٤,٢٥ | ٣,٢١ | ٠,٥٤ | ٤,٣٦ | ٣١٢,٢٥ | ٢,١٣ | ١,٢٤ | ٢٩,٦٥ |
| Genotypes | ١٨ | ١٥٢,٣٨** | ٢١٣٤,٢٥** | ٦٩,٤٢** | ١٠٥,٣٤** | ٧٣٢٢,١٥** | ٥٤,٣٦** | ٣٢,٢٥** | ٩٩٥٤,٣١** |
| Parent | ٦ | ٤٢٨٧,٣٦** | ٥٣٢٦,٤١** | ٥٤,٣٩** | ١٠٠,٢٥** | ٥٤٣٦,٢٨** | ٣٩,٥٦** | ٢٣,٦٤** | ١١٩٥٨,٢٤** |
| P vs C | ١ | ٤٢٢,٣٥** | ٩٨,٤١** | ٣٢٥,٣٦** | ٤٢٦,٣٥** | ٤٧٦٣,٢٥** | ٢٩,٣٥** | ١٤,٢٨** | ١٦٢٥٤,٣٥** |
| Crosses | ١١ | ٢٨٢,٣٦** | ٧٢٦,٥٤** | ٩٧,٣٤** | ٣٤,٢٨** | ٢٦٣٧,٢١** | ٥٤,٢٩** | ١٨,٢٤** | ١٢٣٥٣١,٦٥** |
| Lines | ٢ | ٢١٤,٣٦** | ٣٥٦,٤٧** | ٣٢,٣٦** | ٢٤,٣١** | ١٥٤٦,٣٥ | ٤٤,٣٥** | ٢٢,٣٦** | ١٢١٣٤,٣٦** |
| Testers | ٣ | ٢٤٧,٥٦** | ١٢٣٦,٢٥** | ٢٩,٤٥** | ١٩٨,٣٤** | ٢٢٦٣,٦٥** | ٢٦,٥٤** | ٢٥,١٤** | ٣٢٥٤٧١,٣٥** |
| L x T | ٦ | ٦٠,٢٤** | ٤٠,٦٥** | ١٨,٧٤** | ٤٣,٢٦** | ١٩٧٤,٢٥** | ٢٣.٦٥** | ١١,٧٤** | ٢٤٥٣٢,٤٧** |
| Error | ٣٦ | ٢,٣١ | ٢,٥٧ | ١,٢٤ | ١,٨٣ | ٤٣,٧١ | ٢,٢١ | ١,٣٤ | ٢٦,٢٧ |
| $\sigma^{٢}$ gca | ٦ | ٤٤,٢٣** | ٤,٢٥** | ٢,٣٦** | ٢,١٣** | ٢٩,٥٤** | ٣,٢٥** | ١,٠٢** | ٣٧٧١,٤٦** |
| $\sigma^{٢}$ sca | ١١ | ٢١,٣٦** | ١٥,٣٢** | ١٥,٦٤** | ١٤,٢٧** | ٤٢٢,٦٣** | ١٣,٧٤** | ٩,٧٨** | ١١٢٥١,٥٤** |
| $\sigma^{٢}$ gca / $\sigma^{٢}$ sca | | ٢,٠٩ | ٠,٢٨ | ٠,١٥ | ٠,١٥ | ٠,٠٦ | ٠,٢٣ | ٠,١١ | ٠,٣٣ |
| Cv (%) | | ١,٦٥ | ٠,٩٧ | ٦,٤١ | ٨,٤١ | ٧,٢٩ | ١,٥٤ | ١,٠١ | ١,١٣ |

***and ** significant at ٠,٠٥ and ٠,٠١ levels of probability, respectively.**

**Table ٤: Analysis of variance for combining ability of rice grain quality characters.**

| Source of variance | df | Grain Shape% | Hulling % | Milling % | Head Rice % | Grain elongation % | Gel consistence | Gelatinization temperature | Amylose content % |
|---|---|---|---|---|---|---|---|---|---|
| Replication | ٢ | ٠,٢٨ | ٣,٥٨ | ٢,٨٤ | ١,٩٧ | ٠,٥٢ | ٤,٩٧ | ١,٩٤ | ٠,٤١ |
| Genotypes | ١٨ | ٢٩,٢٣** | ١٩٣,٤٥** | ١٥٨,٢٤** | ١٢٢,٣٤** | ١٢,٣٥** | ١٩٩,٢٣** | ٣٢,٢٥** | ٥٢,٢٣** |
| Parent | ٦ | ٢١,١٩** | ٣٢٧٦,١٦** | ٢٢١١,٣٩** | ١٩٩٧,١٥** | ٩,٧٤** | ٥٣٦٢,١٦** | ٢٩,٤٧** | ٤١,٣٦** |
| P vs C | ١ | ١١,٧٤** | ٣٢٣,٢٩** | ٢٢٤,١٩** | ٢٠٣,١٥** | ١١,٣٦** | ٤٩٧,٢٦** | ٢٣,٢٦** | ٢١٨,٣٤** |
| Crosses | ١١ | ١٥,٣٢** | ٢٧٤,١٣** | ١٧٩,٦٤** | ١٣٣,٢٦ | ١٢,٤٦** | ٣٠٤,٢٦** | ٤١,٢٦** | ٨٣,٢٦** |
| Lines | ٢ | ١٩,٧٤** | ١٩٧,٢٨** | ١٥٠,٢٣** | ٩٩,٢٥** | ١٩,٧٢** | ٢٥٠,٢٧** | ٣٢,٢٦** | ٢٤,٣٦** |
| Testers | ٣ | ٢٠,٤٣** | ٢١٣,٦٩** | ١٩٩,٢٧** | ١٢٣,٢٥** | ٢٠,٧١** | ٢٧٢,٣٦** | ١٩,٧٤** | ٢٠,٢٩** |
| L x T | ٦ | ٩,٢٥** | ٤٩,٢٨** | ٣٥,٢٦** | ٢٩,٧٤** | ٨,٢٣** | ٦٤,٣٦** | ١٧,٦٢** | ١٣,٢٩** |
| Error | ٣٦ | ٢,٠٦ | ٢,١١ | ١,٩٧ | ٢,٣١** | ٠,٣٦ | ٣,٢٥ | ١,٤٩ | ١,٣٢ |
| $\sigma^{٢}$ gca | ٦ | ٢,١٣** | ١٤,٣٦** | ١١,٤١** | ٨,٢٦ | ٠,٢١** | ٤٩,٧٢** | ١,٢٦** | ٣,١٦** |
| $\sigma^{٢}$ sca | ١١ | ٨,٤١** | ٢٥,٣٦** | ٢٢,١٤** | ١٩,٧٤ | ٣,٢٦** | ٣٣,٢٦** | ١٠,٩٤** | ١٤,٨٧** |
| $\sigma^{٢}$ gca / $\sigma^{٢}$sca | | ٠,٢٥ | ٠,٥٦ | ٠,٥٣ | ٠,٤٢ | ٠,٠٦ | ١,٤٨ | ٠,١١ | ٠,٢١ |
| Cv (%) | | ٣,١٢ | ٢,٨٧ | ٦,٢٤ | ٥,٢٩ | ١,٩٧ | ٦,٨٢ | ١,٧٩ | ٧,٢٦ |

***and ** significant at ٠,٠٥ and ٠,٠١ levels of probability, respectively.**

**Table ٥. General combining ability (GCA) effects of yield and its component characters in rice.**

| genotypes | Days to heading (days) | Plant height (cm) | Panicle length (cm) | No. of panicles /plant | No. of filled grains /panicle | Sterility % | ١٠٠-grain weight(g) | Grain yield/plant |
|---|---|---|---|---|---|---|---|---|
| Lines | | | | | | | | |
| GZ-٨٣٧٢-١٣-١-٣-١ | ٥,٢٣** | ٣,١٧** | -١,٨٤ | -١,٤٧ | -٥,٣٤ | ٢,٢٤* | ٠,٨٧ | ٢,١٤* |
| GZ-٨٩٥١-٩-٧-١-٣ | -٤,٩٧** | -٥,٤٣** | ١,٣٩ | ٢,٥٦** | ١٢,٣٦ | ٣,٥٧** | ١,٦٣ | ٣,٥٧** |
| GZ-٨٤٥٥-٦-٨-٣-١ | -١,٠٣ | ٢.٢٤** | -٠,٤٧ | -١,١١* | ٧,١٢** | ١,٣٣ | -٠,٢٦ | -١,٤٣* |
| SE (*ig*) | ٠,٢٧ | ٠,٣٨ | ٠,٨٢ | ٠,٧٣ | -١,٤٣ | ٠,٩٨ | ٠,١٢ | ٠,٢٤ |
| **Testers** | | | | | | | | |
| Sakha ١٠١ | -١١,٣٢** | -١٠,٤٧** | -١,٢٩* | ٢,٤١** | ٢٢,٣٤** | -٨,٤٧** | ٣,٤١** | ١,٦٨** |
| Sakha ١٠٢ | ٣,٥٤** | -١١,٧٨** | ٤,٢٦** | -٥,٢٦** | -٧,٢٦** | -١١,٢٥** | -٤,٧٢** | -٥,٤٩** |
| Sakha ١٠٣ | ٥,٣٥** | ٥,٤١** | ١,٧٩* | -٢,٨٤** | -٦٩,٤٥** | ٣,٩٧* | -٢,٧٩* | ١,٣٦* |
| Sakha ١٠٤ | ١٩,٢٨** | ١٦,٣٨** | -٤,٣٩ | -٥,٩٧** | ٤٠,٢٨** | ١٥,٤٢** | ٣,٤٧** | ٣,٢٧** |
| SE (*ig*) | ٠,٩٦** | ٠,٧٢ | ٠,٤٦ | ٠,٥٤ | ١,٩٧ | ٠,٨٣ | ٠,٢٧ | ٠,٥٣ |

***and ** significant at ٠,٠٥ and ٠,٠١ probability levels, respectively.**

**Table ٦. General combining ability (GCA) effects of grain quality characters in rice.**

| genotypes | Grain Shape% | Hulling % | Milling % | Head Rice % | Grain Elongation % | Gel Consistence | Gelatinization Temperature | Amylose content % |
|---|---|---|---|---|---|---|---|---|
| Lines | | | | | | | | |
| GZ-٨٣٧٢-١٣-١-٣-١ | ٠,٦٣ | ٤,١٢** | -٣,٢٦** | ٢,٩٧** | ٠,٦٣** | ٢,٩٧** | -٢,٣١** | ٣,٢٦** |
| GZ-٨٩٥١-٩-٧-١-٣ | ١,٢٥ | -٣,٦٢** | ٤,٣٩** | ٣,٢٦** | ٠,٩٦** | ٥,٢٦** | ١,٩٧** | -٦,٩٧** |
| GZ-٨٤٥٥-٦-٨-٣-١ | ٠,٦٣ | -١,١٣ | -١,٩٧** | ٠,٢٩ | ٠,٣٣* | ٢,٢٥** | ١,٢٥* | ٢,٩٥** |
| SE (*ig*) | ٠,١٤ | ٠,٣٧ | ٠,٤٢ | ٠,٣٢ | ٠,٠٥ | ١,٣٥ | ١,١١ | ١,٠٢ |
| **Testers** | | | | | | | | |
| Sakha ١٠١ | -١,١٦** | ٩,٧٤** | ٨,٢٧** | -٤,٤١** | ٢,٢٥** | ١٠,٤١** | ٣,١٥** | -٤,٢٨** |
| Sakha ١٠٢ | -٣,٥٤** | -١٠,٧٤** | ٩,٧٤** | -٦,٣٤** | ٢,٢٤** | ٩,٦٣** | ٥,٧٤** | ٦,٢٧** |
| Sakha ١٠٣ | -٢,١٦** | -١١,٦٢** | ٥,٩٧** | ٢,١٨** | -١,٦٩** | -٤,٢٥** | ٤,٣١** | ٨,٥٤** |
| Sakha ١٠٤ | ٦,٢٩** | ١٢,٦٣** | ١٢,٦٣** | ٨,٤٧** | -٣,٢٥** | -١٥,٢٦** | -٧,٢٥** | -١٠,٢٦** |
| SE (*ig*) | ٠,٤٣ | ٠,٥٤ | ٠,٦٤ | ٠,٥١ | ٠,١١ | ٢,٣٦ | ٠,٨٤ | ١,٤٥ |

***and ** significant at ٠,٠٥ and ٠,٠١ probability levels, respectively.**

**Table ٧. Specific combining ability (SCA) effects for grain yield and its component characters in rice crosses.**

| genotypes | Days to complete heading(days) | Plant height (cm) | Panicle length (cm) | No. of panicles /plant | No. of filled grains /panicle | Sterility % | ١٠٠-grain weight(g) | Grain yield/plant |
|---|---|---|---|---|---|---|---|---|
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ | ٣,٢٦* | -٢,٩٧* | ٢,٣٦** | ٥,٨٩** | ١١,٤٧** | -١,٥٣ | ٠,٤٥ | ٩,٢٥** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٢ | ٢,٦٣ | ٤,٣٦** | -١,٤٥ | -٢٥,٦٧** | -١٤,٦٣** | ٥,٤٧** | -٣,٢٧** | -٨٦,٤٥** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٣ | ٧,٤١** | ٢,٥٧* | ١,٩٧** | ١,٩٧ | -٥,٤٦** | ١,٢٩ | ٠,٩٢ | -٦٣,٢٥** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ | -٦,٢٦** | -٧,٤١** | ٠,٠٩ | ٢,٨٦* | ٢٢,٤٧** | -٢,٦٤** | ١,٤٦* | ١٠,٢٦** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ | ٢,٩٧* | ٢,٩٦* | ١,٥٣* | ٧,٥٨** | ٩,٤١** | ١,١١ | ٠,٨٤ | -٥٤,٢٣** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ | -١,٢٩ | -٤,٢١** | -١,٠٩ | ١١,١٧** | -٤,٢٦** | ٠,٩٦ | ٠,١٢ | ٣٥,٢٦** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ | -٤,٢٥** | ٠,٦٩ | -١,٢٨* | -٢٦,٨٢** | ٣,٩٧* | ٠,٧٩ | ٠,٢٨ | ٦٤,٢٤** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤ | ٢,٦٩* | -٣,٢٥* | ٢,٨٤** | ٢٩,٧٤** | ١٩,٧٤** | ٠,٤٦ | ٠,٣٢ | ١٢٠,٣٦** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ | ٢,٨٤ | ٣,١٧* | -١,٩٢** | -١٢,١٥** | ٩,٧٤** | -١,٩٧** | ٠,٨٩ | ٥٠,٣٨** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ | -٠,٨٤ | -١,٢٦ | ٠,٩٧ | -٢,٣٦* | -٩.٨٧** | ٦,٤٢** | ٣,٩٦** | -٤٩,٢٨** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣ | ١,٩٧ | ٢,٤٥* | -٢,٤٣ | ٢١,٤٧** | -٨,٢٧** | ٠,٥٣ | ٠,٣٤ | -١١٠,٣٤** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ | ٣,٢٥** | ٥,٢٧** | ٢,٦٣** | ١٢,٦٢** | ٩,٤٥** | -٢,٩٧** | ١,٨٤* | ١٠٢,٣٦** |
| SE (*ijs*) | ١,٢٢ | ١,٦٣ | ٠,٦٥ | ٢,٦٣ | ١,٩٨ | ٠,٨٤ | ٠,١٤ | ٣,١٢ |

***and ** significant at ٠,٠٥ and ٠,٠١ levels of probability, respectively.**

**Table ٨. Specific combining ability (SCA) effects for grain quality characters in rice crosses.**

| genotypes | Grain Shape% | Hulling % | Milling % | Head Rice % | Grain elongation % | Gel consistence | Gelatinization temperature | Amylose content % |
|---|---|---|---|---|---|---|---|---|
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ | ٠,٦٤ | ٢,٢٦* | ٢,٥٤* | ٢,٠٣** | ٠,١٢ | ٣,٤١* | -١,٤٧ | ٢,٤٧ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٢ | -٢,٩٧** | -٤,٩٦** | -١,٢٢ | -١,٦٩* | -١,٤٢** | ٥,٢٦** | ٣,٥٢** | ٤,٢٥** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٣ | -٠,٨٢ | -٣,٧٤*** | -١,٣٦ | -١,٢٣ | ٠,٣٧ | -٣,٩٧** | -١,٤٦ | -٢,٣٥ |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ | ٢,٤١** | ٩,٧٢** | ٣,٧٤** | ٢,٩٧** | -١,٢٦** | ٧,٢٩** | ٣,٥٤** | ٤,٨٩** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ | ٠,٦٣ | ٤,٢٦** | ١,٢٧ | -١,١٢ | ٠,٣٢ | -٣,٧١** | -١,٢٦ | ٢,٤٨ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ | -٠,١٤ | -٥,٤١** | -١,١١ | -٠,٩٩ | ٠.١١ | -٤,٢١** | -١,٢١ | -٢,٤١ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ | -٠,٤٦ | -١,٠٩ | -١,١٦ | -١,١٢ | ٠,٢٣ | -٢,٣٦ | -١,٩٧ | -٣,٢٥** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤ | ٠,٣٩ | -٣,٩٧** | -٣,٢٥** | ٣,٠٨** | ٠,٢١ | -٣,٢٧** | ١,٢٨ | -٢,٩٧* |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ | ٠,٩٧ | ٤,٢١** | ٣,٧٤** | ٢,٤١** | ٠,٣١ | ٤,٢٥** | -٢,٣١ | ٣,٢٨** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ | -٤,٢٦** | -١,٢٢ | ٠,٩٨ | -١,٨٤ | ١,٩٧** | -٢,٤١ | ٣,٤٧** | ٤,٦١** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣ | ٠,٩٤ | -٣,٢٥** | -٢,٤٩ | -٢,٨٣ | ٠,٣٦ | -٣,٦٩** | -٢,٠٩ | -٣,٩٧** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ | ٢,٠٩** | ٦,٤١** | ٥,٤١** | ٤,٢١** | ١,٢٥** | ٥,٩٧** | -٣,٩٧** | -٥,٤٢** |
| SE (*ijs*) | ٠,١٢ | ١,٨٤ | ١,٠٣ | ٠,٩٧ | ٠,٠٤ | ٢,٠٨ | ٠,٤٨ | ١,٤٢ |

***and ** significant at ٠,٠٥ and ٠,٠١ levels of probability, respectively.**

**Table ٩. Estimates of Heterobeltiosis (Hb) for yield and its component characters in rice crosses.**

| genotypes | Days to complete heading (days) | Plant height (cm) | Panicle length (cm) | No. of panicles /plant | No. of filled grains /panicle | Sterility % | ١٠٠-grain weight(g) | Grain yield/plant |
|---|---|---|---|---|---|---|---|---|
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ | ٠،٩٦ | ٧،١٤** | -٤,٢٦** | ٣،٨٤** | -٠،٦١ | ٧،١٤** | -١،٥١ | -٨،١٦** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٢ | ٥،٢٦** | -٠،١٩ | -٤،٣٤** | -٣،٨٤** | -١٠،٦٦** | -١،٤٠ | ١،١٥ | -١٤،٢٨** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٣ | ٦،٩٣** | ٢،٠٢ | -٢،٩٥ | -١١،٥٣** | -٠،٦٦ | ٧،١٤** | -٣،٤٦** | -١٠،٢٠** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ | ١،٤٨ | ٢،٨٠* | ٤،٣٤** | -٢٣،٠٧** | -٩،٣٣** | ١٤،٢٨** | ٣،٣٣** | ٦،٦٠** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ | -١،٤٦ | ٢،٠٤ | ٣،٨٤** | ٢٢،٧٢** | ١،١٨ | -٥،٠٦** | ١،١٥ | ٢،٠٨** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ | ٥،٢٦** | ٢,١٢ | -١،٥١ | ٢٥,٤٥** | -١٥،٩٦** | -٧،١٤** | ٠،٤٢ | -١٠،٤١** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ | ١،٩٨ | ٢،٠٢ | -٧،٦٩** | ٣٠,٢٤** | -٨،٢٨** | -٦،٢٥** | ١،٦٤ | -١٤،٥٨** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤ | ١،٩٦ | ٢،٨٥* | -٢،٣٤ | -٥,٦٣** | -٢٠،١١** | ٦،٦٦** | -٢،٥٩* | -٢،٠٤ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ | ٣،٠٣** | -١٢،٥** | -٤,٣٢** | -٤،١٦** | -١،٧٤ | ١٣،٣٣** | ١،١٥ | -٢،١٧ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ | ٣،١٥** | ٢،٠٨ | -٤,٥٤** | -٤،١٦** | -١٦،٢٧** | ١٤،٢٨** | ٠،٤٣ | -٨،٦٩** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣ | ٣،٠٣** | ٧،٢٩** | -١،٥٧ | -٨،٣٣** | -٨،١٣** | -١،٩٦ | ٢،٤٦ | -١٣،٠٤** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ | -٢،٠٢* | -١٠،٤١** | -٢،٣٤ | -٤،١٦** | -٦،٩٧** | -٦،٢٥** | -٢،٢٢ | -١٠،٤١** |

***and ** significant at ٠,٠٥ and ٠,٠١ levels of probability, respectively.**

**Table ١٠. Estimates of Heterobeltiosis (Hb) for grain quality characters in rice crosses.**

| genotypes | Grain Shape% | Hulling % | Milling % | Head Rice % | Grain elongation % | Gel consistence | Gelatinization temperature | Amylose content % |
|---|---|---|---|---|---|---|---|---|
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠١ | -٧،٦٩** | -٠،٤٨ | ١،٣٦* | ٠،٤٣ | -١١،٣٩** | -٢،٢٢ | ٣،١٢** | ٢٢،٢٢** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٢ | ٣،٨٤** | ١،٢٥* | -١،٣٤* | -٠،٢٩ | -١،٤٠ | -٥،٥٥** | ١،٦١ | ٣١،٥٧** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٣ | -٣،٨٤** | ١،٢٦* | -٤،١٠** | -٤،٤١** | -٣،٦٥** | -٢،١٥ | ١،٥٦ | ٢٧،٧٧** |
| GZ-٨٣٧٢-١٣-١-٣-١ x Sakha ١٠٤ | -٣،٨٤** | -١،٢٣* | ١،٣٥* | ١،٤٧ | -٣،٨٤** | -٢،١٩ | ١،٥٨ | ٦،٢٥** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠١ | -٤,٢٦** | ١،٢١* | -٠،٤٠ | -١،٤٤ | -٥،٠٦** | -١،١١ | -١،٥٦ | -٢،٥٦ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٢ | ٤,٣٤** | -١،٢١ | -٢،٧١** | -٧،٩٥** | -٢،٧٧* | -٢،٢٤ | -١،٥٨ | -١،٥٥ |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٣ | -٤,٨٧** | -٢،٤٣** | -١،٣٥ | -٠،٦١ | -٧،٣١** | -١،٠٧ | -١،٥٣ | ٥،٥٥** |
| GZ-٨٩٥١-٩-٧-١-٣ x Sakha ١٠٤ | -٣،١٠** | -٢،٤١** | -٤،٠٥** | -٢،٩٤ | -٣،٨٤** | -٤،٣٩** | -٠،٧٨ | ٢٥,٣١** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠١ | ٨،٣٣** | ٤،٨١** | ٥،٤٠** | ١٤،٤٧** | -١٠،١٢** | -٠،٥٥ | ٦،٢٥** | -٥،٧٠** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٢ | ٤،١٦** | -١،٢٠ | -١،٢٠ | -٧،٤٦** | ٧،٣٥ | ٣،٣٧** | ١,٥٨ | -٢،٥٥ |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٣ | ٨،٣٣** | -٣،٦١** | -٤،٠٥** | -٢،٩٨ | -١٠،٩٧** | -١٠،٧٥** | -١،٦١ | ٥،٥٥** |
| GZ-٨٤٥٥-٦-٨-٣-١ x Sakha ١٠٤ | -٤،١٦** | -٦،٠٢** | -٥،٤٠** | -٤،٤٧** | -٧،٦٩** | -٦،٥٩** | ٤،٦١** | -٣،٠٣** |

***and ** significant at ٠,٠٥ and ٠,٠١ levels of probability, respectively.**